It is with pleasure that I dedicate this species to Professor W. C. Knight, geologist and palæontologist and whilom botanist, to whom I am often indebted for specimens, and who first called my attention to this form.

This shrub-like tree is common in the so-called cedar bluffs, red sandstone hills, occurring at intervals throughout the Red Desert region of Wyoming from the Seminoe mountains to Green river. It was observed by the writer in numerous localities during the summer of 1897, the accompanying figure being from a photograph secured at Point of Rocks. The habit as shown is not only characteristic but nearly universal. One is reminded of the recently published illustration of Dr. Sargent's *J. scopulorum*,[3] which is scarcely characteristic of that species as I know it in the hills about Laramie.

The two foregoing are the only tree-like junipers that have yet been secured in the state, but one or two others may possibly be found within our borders to the west and north. Of the shrubby forms the following are abundant: *J. communis* L., *J. communis Sibirica* (Burgsd.) Rydb., and *J. Sabina* L.—AVEN NELSON, *The University of Wyoming.*

THE MORPHOLOGICAL SIGNIFICANCE OF THE LODICULES OF GRASSES.[4]

THE question of the morphological significance of the lodicules in the grasses has been discussed by very many botanists during the last hundred years. The last author, of which I know, to deal directly with the subject was Dr. Edward Hackel, the eminent agrostologist, who in his paper published in the first volume of Engler's *Botanische Jahrbücher* (1880), treats the question so exhaustively that his conclusions, supported as they are by his careful researches and to some extent no doubt by his great reputation as a student of the grasses, have for more than twenty-five years been accepted as the true interpretation of these organs. A glance at his historical résumé shows that, in the main, two views have been held by botanists: first, that these organs constitute a rudimentary perianth, to which view a considerable number, especially of the older botanists, gave adherence; and second, that they are remnants of bracts in morphological value the equivalent of leaves. To the latter view Hackel, as well as other earlier writers, held.

[3] Garden and Forest **10**: 423. 1897.
[4] Read at the Ithaca meeting of the Society for Plant Morphology and Physiology.

It is important at the outset to point out that in other orders of monocotyledons the problem would be less important and indeed less easy of solution, since there frequently occur in them species exhibiting a complete transition from the bracts of the flower cluster to the leaves of the perianth. In the grasses, however, the true leaves are always distichous, while the sporophylls of the gynoecium as well as the androecium are in threes. The interpretation must mainly depend then upon the demonstration of the trimerous disposition of the lodicules on the one hand, or on their distichous arrangement on the other.

Either interpretation may presuppose the suppression of whole whorls or of parts of whorls or of bracts; the union of parts of the same set; the adhesion of superimposed sets or superimposed leaves. Hackel studied first the development of the lodicules on a considerable number of species, mostly European; second, he made a comparative study of mature lodicules; and third, he studied their anatomy. His conclusions are as follows:

1. "The anterior lodicules are to be regarded as the lateral halves of a leaf alternating with the palet (Vorspelze), the middle part of which only in rare cases develops either partly or entirely.

2. The anterior lodicules, arising as they do from a single simple rudiment (Anlage), experience in their growth various arrests through the more rapid growth of neighboring organs; they develop very often on their posterior border outgrowths in the form of teeth and lobes which, taken together with the before mentioned conditions, lead sometimes to the lodicules appearing dissected into distinct and even into superimposed lobes, whereby the appearance is sometimes presented of an aggregation of lodicules from separately inserted leaf structures.

3. The anterior lodicules are independent of the palet, although they sometimes unite mechanically with its margin, however, without organic union; they too develop later; are inserted higher on the axis than the palet; and in their tissue structure differ widely from it. The delicate bundles of the lodicule do not unite with those of the palet but join the axillary bundle independently. Lobes and stipular structures of the border of the palet, which sometimes occur, need never be confused with lodicules.

4. The posterior lodicules of the Stipaceæ investigated, and probably in all grasses where they are present, are really later to appear

than the anterior and are also probably inserted somewhat higher on the axis. Consequently the lodicules, when all are present, continue the distichous arrangement of the palet and glume."

In accordance with these conclusions, Hackel formulated his interpretation of the organs of the flower in grasses. It may be noted that Hackel expresses doubt about his interpretation of the significance of the posterior lodicule.

Usually the bamboos have the posterior lodicule present and, in a few species, there normally develop two trimerous whorls of lodicules. Last summer a bamboo (*Arundinaria falcata*) produced flowers in the University garden and the writer took the opportunity to study the flowers in detail with special reference to Hackel's conclusions.

Warming in his *Systematic Botany* (p. 291) regards the Bambuseæ as the most primitive of the tribes of the Gramineæ, and it seems to me that a fair consideration of their floral structure and their geographical distribution bears out his opinion. He also states the theory of the grass flower substantially as the writer is about to present it, but he gives this theory in brackets after having in the preceding paragraph given the bract theory in italics. If the bamboos be the most primitive of the grasses, then surely the lodicule in this group of plants ought to shed light on the question of their morphological significance.

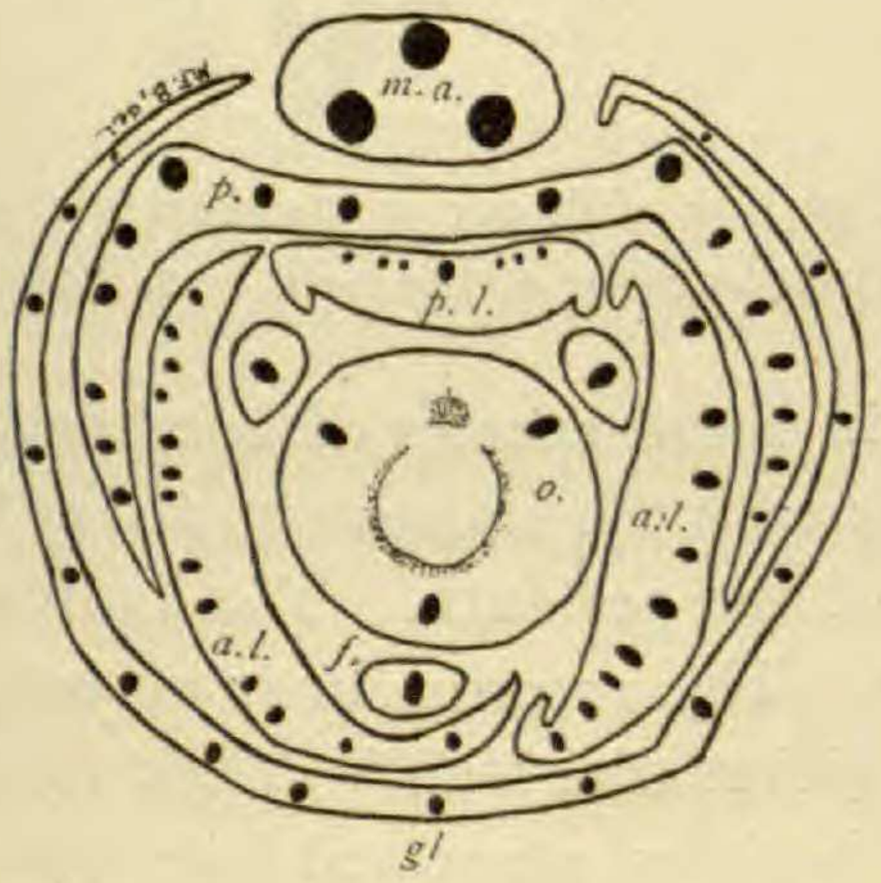

FIG. 1.—Cross section of flower of Arundinaria with subtending glume and palet: *m. a.* main axis; *gl.* flowering glume; *p.* palet; *a. l.* anterior lodicules; *p. l.* posterior lodicule; *f.* filament; *o.* pistil.

Serial cross and longitudinal sections of the flower were made and figs. 1 and 2 are representations of what was found.

There occur in the ovary walls the three midribs of the coherent

carpels. That these are midribs is the more certain since the suture upon which the single ovule is borne is midway between two of them. The ovule is borne upon the posterior side of the ovary. The stamens in this species stand directly opposite the midribs of the carpels. The

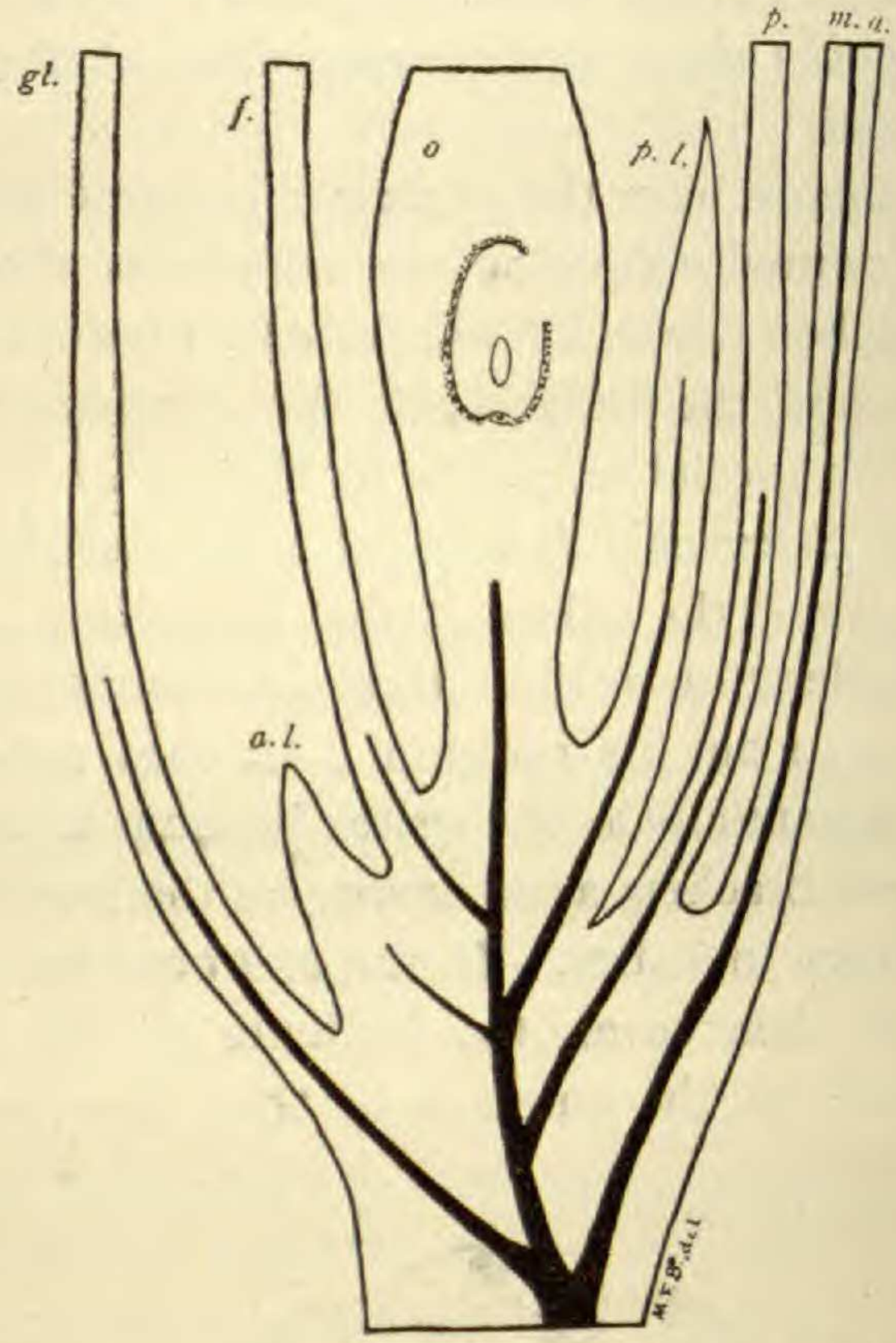

FIG. 2.—Longitudinal section of flower of Arundinaria, with particular reference to the insertion of the vascular bundles of the lodicules. Lettering same as in *fig. 1.*

inner whorl, present in some species of bamboos, is suppressed here. The lodicules alternate with the stamens and may be considered therefore the inner whorl of the perianth. The lodicules are all alike in form and in structure. The anterior ones do not give the impression of being "the lateral halves of a leaf." Their inturned margins, symmetrically distributed bundles, narrowed base, and trimerous arrangement with the posterior lodicule, make it very certain that they are foliar units, the equivalents of petals. As to the height of insertion of the posterior lodicule, there can be no doubt but what, in our plant, it is inserted higher on the axis than the anterior ones. This condition might reasonably be expected where organs are crowded together so closely as on the posterior side of this flower. That the place of inser-

tion is of little importance in this regard is shown by the fact that the palet also is inserted above the anterior lodicules. Tracing down the vascular strands of the three lodicules, they are found to unite with the central strand of the axis at approximately the same point, while the vascular strands of the palet unite with the axial strand below the insertion of the strands of the lodicules. The insertion is disguised by the adhesion of the palet to the posterior lodicules.

Hackel in his discussion neglected the general law which governs the arrangement of leaves on a branch among the grasses. As is well known, the leaves on a branch are inserted in a plane at right angles to the plane in which the leaves on the main axis are borne. Hackel's conclusions reverse this law and maintain that the leaves (lodicules) on the floral branch are in the same plane as the leaves (glume and palet) on the primary axis. Such a departure from normal arrangement is scarcely probable.

It seems to me that Hackel attaches too much importance to the fact that the lodicules appear as a single rudiment afterwards becoming two-lobed. The rudiment (Anlage) of the corolla in a great many plants arises as a continuous collar of the receptacle, and afterwards the lobes are differentiated.

The question is one of considerable moment. Taking one view there is more reason for believing the grasses a group connected by intermediate forms to other monocotyledons; taking the other, the grasses must stand as a more isolated group, and the recent assumption that they are but very remotely connected genetically with other monocotyledons would have more to support it. The question also bears on the primitive character of the bamboos. — W. W. ROWLEE, *Cornell University*.